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Smartphone ocular check application accuracy in comparison to traditional test for Saudi school children

Farah Maqsood✉, **Eman A Alzawadi**

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Author Affiliation:
Department of Optometry and Vision Science, College of Applied Medical Sciences, King Saud University, Riyadh 11451, Saudi Arabia

✉**Corresponding author**
Department of Optometry and Vision Science, College of Applied Medical Sciences, King Saud University,
Riyadh 11451, Saudi Arabia
Email: fmaqsood@ksu.edu.sa, farahmaqsood@gmail.com

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ABSTRACT

Purpose: Visual acuity screening in children during and after the Covid-19 pandemic by recommending parents a free and easy Ocular Check Application. *Methods:* Visual acuity (VA) test were conducted for 86 eyes of 43 subjects between the age of 5 to 13 years, using both gold standard chart and Ocular Check application. The participants had gone through ocular screening to avoid amblyopia, strabismus or any ocular pathology. Many tests for screening were done like external eye exam, cover and uncover, light reflex, and ocular alignment examinations. *Results:* The median VA logMAR of all eyes tested using Standard and Ocular Check application were 0.0 LogMar. Intraclass Correlation Coefficient (ICC) showed a strong positive correlation between the two charts (ICC=0.857; P<0.001) in total number of eyes. In addition, a strong positive correlation was also found between the two charts for each eye (OD: ICC=0.845; P<0.001, OS: ICC=0.87; P<0.001). *Conclusion:* VA measurements with Ocular Check application corresponded well to the standard chart, suggesting potential utility of alternative portable VA tests for in-office or remote vision monitoring, particularly during the curfew time in pandemic situation of Covid 19.

Keywords: Public health; Vision screening; Visual acuity; Ocular Check application; Standard chart.

1. INTRODUCTION

Globally 2.2 billion people are visually impaired or blind, out of which around 1 billion cases are avoidable as reported by World Health Organization (WHO) (Steinmetz et al., 2021). Visual impairment impacts overall quality of life like self-independency, protection, education, employment, and psychological effects etc. (Varma et al., 2006). Technological advancement has affected human habits and lifestyles like early morning newspapers have been replaced by the electronic gadgets such as screens of smartphones and televisions (Pathipati et al., 2016; Evans & Rowlands, 2004). Public health emergency has been declared by the WHO regarding the outbreak of COVID-19 because millions of people have been infected plus thousands of deaths have been reported worldwide because of COVID-19 (Xu et al., 2020).

Children spend more time on electronic gadgets than the other physical activities due to online teaching, internet surfing and video games also. The use of technologies in numerous areas has even increased because of lockdown in this pandemic (Sidikova et al., 2019). More regular routine eye checkups are recommended for healthy population also, but during pandemic many people are ignoring routine health checkups to avoid highly crowded places including hospitals. Optometrists assess the visual impairment using various methods for visual acuity screening, to decide on the urgency of the treatment (Perera et al., 2015; Tiraset et al., 2021). The use of smartphone devices in the medical field has been expanding at a gallop. It is important that these technologies should be validated to be used by the patients themselves especially in developing countries with limited opticians (Bastawrous et al., 2015). Han et al., (2019) reported that physical checkups at a clinic can be a barrier to mobility impaired, elderly, and rural patient's therefore smartphone-based applications enable the patients to easily test and monitor their visual acuity at home.

The EyeChart apps for visual acuity screening are free to download which makes attractive to patients who want to screen their own visual acuity between the appointments (Black et al., 2013; Brady et al., 2015; Samanta et al., 2020). More than 1 million Eye Chartapps are already downloaded in spite of no published research into its accuracy (Di et al., 2020). This study was done to investigate if the EyeChart app for iPhones gives accurate visual acuity measurements as compared to the traditional Snellen chart, and the gold standard Early Treatment Diabetic Retinopathy Study (ETDRS) chart in Saudi children.

2. MATERIALS AND METHODS

This cross-sectional study was done in Al-Maghrabi hospital, Riyadh from January to May 2021. Approval (IRB Approval ID E-20-5624) to conduct this study was obtained from the office of Human Research Protection (OHRP), College of Medicine, King Saud University, Riyadh, Saudi Arabia in April 2021. Informed written consent from the children's parents was obtained before inclusion in the study and participants were having the opportunity to withdraw from the study at any time without any consequences. The participants were 43 children, both boys and girls of age range 5-13 years. Children with strabismus, amblyopia, or any ocular pathology were excluded and participants with refractive errors were instructed to wear their spectacles (Ansell et al., 2020). This study was done using the OcularCheck application which is developed by Soham Govande et al., (2021). It was established on application store against, the tumbling E chart and Lea symbols chart.

Ocular Check application is available free on Android Google Play Store and the iOS App Store and can be used without any professional training to test the Distance Visual Acuity (DVA). This application has many useful features such as high device compatibility, diagnostic accuracy, auditory guides, multilingual optotypes and no need of internet connection. It was installed on an iPhone X (iOS 14.6). The light of the phone will be turned to high automatically when the test starts whatever it was in setting. The application gives some instructions in the beginning for distance as the person who is under the test should stand 10 ft (3.05m) away from the device and after that ask how to apply the test by an assistant to operate the device. As the patient under the test finished reading each line, the assistant should select a bottom of the screen that corresponds to how many letters were read by the patient (like "All correct", "1" incorrect, "2" incorrect or"more than2"). It also provides pictures of the distance, how the device should be on a location that the screen faces the person under the test and at his/her eye level and how to hold the device steadily by using a support. After the setting it shows many optotypes chart such as Snellen, Tumbling E, Lea Symbols, ETDERS, and more. It gives the choice of from which row you want to start the test, also the choice of testing monocular or binocular and the repeatability of the test.

Once the test starts, it guides the user to cover the untested eye after that it tests the right eye first followed by the left eye and then both eyes. After the test, the results display as LogMar fraction or Snellen (feet) with as the assistant set the application beside some recommendations to visit a professional as needed. The data collection was done by the two trained examiners with well controlled testing distance, refraction error correction, and illumination. Both examiners were unaware of each other's results in order to avoid any type of partiality.

Design and Procedure

All the participants underwent ocular screening tests such as pupil examination, red-light reflex test, ocular alignment test, cover and uncover test, and external eye exam to eliminate amblyopia, strabismus, or any ocular pathology. All the tests were done monocularly with covering the untested eye by hand first, and thenallows the participant to rest his/her eyes for 30 to 60 second to avoid eyes fatigue. For the children of age 5-6 years Lea symbols chart was used and the Tumbling E chart was used for the ages between 7-13 years.

Statistical Analysis

Averages for normally distributed variables are given as mean ± standard deviation. For non-normally distributed variables, median and interquartile range was taken. Correlation plots and Bland–Altman plots had been selected to check the similarity in visual acuity data sets. To check interrelation significance among the data sets taken by two different methods, the intraclass correlation coefficient was adopted. The statistical significance was defined as $p<0.05$ and 95% confidence intervals (CI) were determined to check the disparity between the medians or means.

3. RESULTS

The study included 43 children (86 eyes) of mean age 10.16 ± 2.9 years. Twenty three (53.5%) participants were females out of the total participants the educational level of participants was within middle school and under and mostly the participants were within middle income and with clear medical condition. Therefore, the refractive errors for all the participants were better than 0.4 logMAR. Fourteen (32.6%) participants received correction for refractive errors prior to visual acuity testing. Most of the charts displayed were Tumbling E type (86%), while Lea Symbols chart was displayed for 6 participants (14%). Demographic data including gender, age and educational level were noted and given in Table 1.

Table 1 Demographic Data.

		Mean	**Standard Deviation**	**Count**	**Column Valid (n %)**
Age		10.16	2.90		
Gender	Female			23	53.5%
	Male			20	46.5%
Correction	Yes			14	32.6%
	No			29	67.4%
Educational level	Below primary school			3	(7%)
	Primary school			24	(55.8%)
	Middle School			16	(37.2%)
Chart display	Tumbling E			37	86.0%
	Lea symbols			6	14.0%

The median visual acuity measured using the standard chart and app chart was 0.0 logMAR (IQR 0.0, 0.2) and 0.0 logMAR (IQR 0.0, 0.1) respectively for the total eyes, with a median difference of 0.0 logMAR (IQR 0.0, 0.0). For the right eyes (OD) the median visual acuity was 0.0 logMAR (IQR 0.0, 0.2) using the standard chart, and 0.0 logMAR (IQR 0.0, 0.1) using the app chart. Regarding the left eyes (OS), the median visual acuity was identical for both standard chart and app chart measuring 0.1 logMAR (IQR 0.0, 0.2) (Table 2).

Intraclass Correlation Coefficient (ICC) showed a strong positive correlation between standard chart and app chart (ICC=0.857; $P<0.001$) in the total number of eyes. In addition, a strong positive correlation was also found between the two charts for each eye (OD: ICC=0.845; $P<0.001$, OS: ICC=0.87; $P<0.001$) as given in Table 3 and Figure 1. In Figure 2, Bland-Altman plot shows the variation in LogMar visual acuity scores between standard chart and app chart.

Table 2 Visual Acuity Comparison between Standard chart and App Chart.

Visual acuity measurement, logMAR	Total eyes (n =86)	OD (n = 43)	OS (n = 43)
Standard chart, median (IQR)	0.0 (0.0, 0.2)	0.0 (0.0, 0.2)	0.1 (0.0, 0.2)
App chart, median (IQR)	0.0 (0.0, 0.1)	0.0 (0.0, 0.1)	0.1 (0.0, 0.2)

Abbreviations: OD, oculus dexter (right eye); OS, oculus sinister (left eye); n, number and IQR, interquartile range.

Table 3 Intraclass Correlation Coefficient analysis

	Number of eyes	Intraclass Correlation	95% Confidence Interval		*P*
			Lower Bound	Upper Bound	
Standard chart vs App chart all eyes	86	0.857	0.781	0.907	< 0.001*
Standard chart OD vs App chart OD	43	0.845	0.714	0.916	< 0.001*
Standard chart OS vs App chart OS	43	0.87	0.759	0.93	< 0.001*

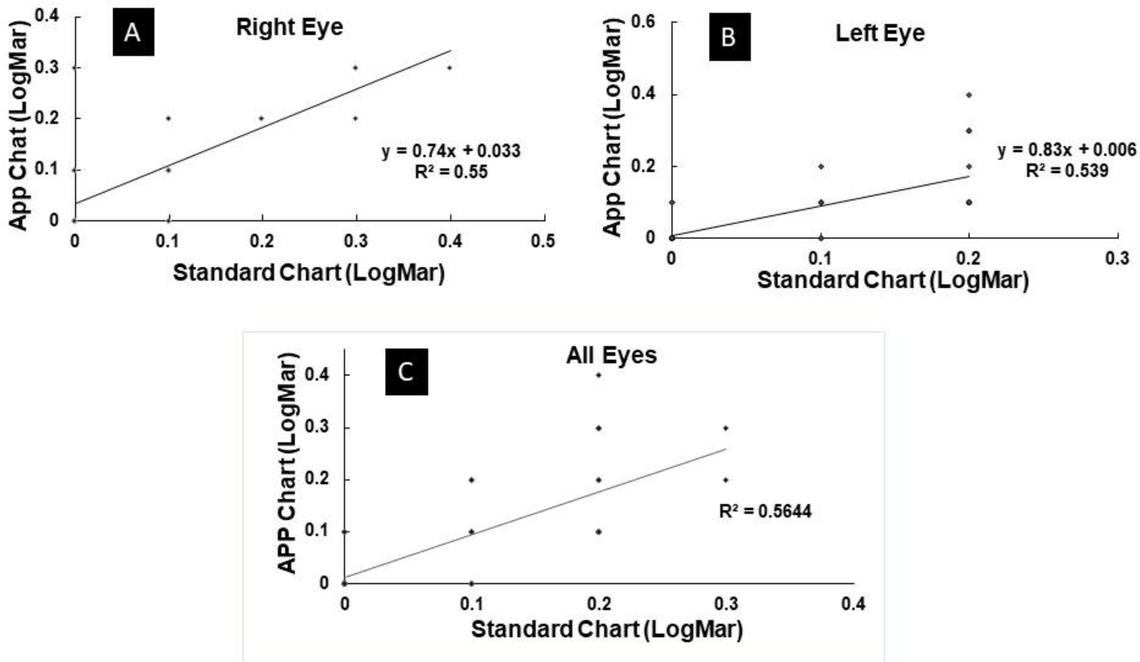

Figure 1 Correlation between Standard Chart and App Chartfor (A) Right eyes, (B) Left eyes and (C) All eyes.

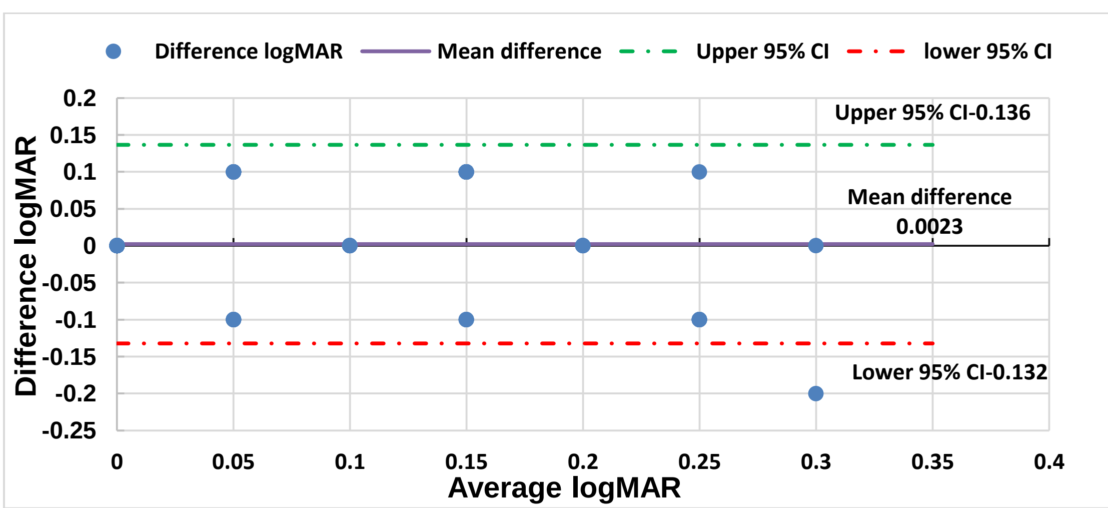

Figure 2 Bland-Altman plot showing the variation in LogMar visual acuity scores between standard chart and app chart.

4. DISCUSSION

This study indicates that visual acuities measured using Ocular Check Application are unvarying and in pretty good deal with those investigated using the standard charts with a median difference of 0.0 logMAR.A strong positive correlation between the standard chart and the app chart is found with p value of less than 0.001. However, Ansell et al., (2020) reported a difference of 0.02 logMAR between the app chart and ETDRS chart. Other study done by Bastawrous et al., (2015) reported a difference between smartphone and ETDRS and smartphone and Snellen acuity data 0.07 and 0.08 respectively. The median visual acuity difference had been observed 0.0 logMAR between the both eyes (right and left). Bastawrous et al., (2015) concluded that 1acuity smartphone test is competent to give precise measurements. A study conducted by Tiraset et al., (2021) in Thailand reported similar results. Other studies also demonstrated that the visual acuity measurements using eye chart app or smartphone-based eye chart correspond well to the ETDRS (Ansell et al., 2020, Tiraset et al., 2021).

Limitations

This study was done on a small sample size of age group 5-13 years using iPhone X. To validate these results, further research is needed on different age groups using other electronic gadgets.

5. CONCLUSION

In this study, visual acuity measurements scored on the OcularCheck application are found comparable to those scored on the standard chart suggesting the possibility of the use of smartphone applications for remote vision monitoring. The validation of smartphone based visual acuity measurement procedures may have feasibility during Covid-19 pandemic.

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Authors Contributions

Farah Maqsood: Established the study design, supervised it and prepared manuscript.

Eman A. Alzawadi: Conducted the field work, did the data analysis and literature search.

Ethical approval

The study was approved by the Medical Ethics Committee of Human Research Protection (OHRP), College of Medicine, King Saud University, Riyadh, Saudi Arabia. University (ethical approval code: E-20-5624).

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Conflict of interest

The authors declare that there are no conflicts of interest.

Data and materials availability

All data associated with this study are present in the paper.

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